Water Supply Planning in Virginia: The Future of Groundwater and Surface Water

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Sea Grant Virginia

2018

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About the Virginia Coastal Policy Center

The Virginia Coastal Policy Center (VCPC) at the College of William & Mary Law School provides science-based legal and policy analysis of ecological issues affecting the state's coastal resources, by offering education and advice to a host of Virginia's decision-makers, from government officials and legal scholars to non-profit and business leaders.

With two nationally prominent science partners – the Virginia Institute of Marine Science and Virginia Sea Grant – VCPC works with scientists, local and state political figures, community leaders, the military, and others to integrate the latest science with legal and policy analysis to solve coastal resource management issues. VCPC activities are inherently interdisciplinary, drawing on scientific, economic, public policy, sociological, and other expertise from within the University and across the country. With access to internationally recognized scientists at VIMS, to Sea Grant's national network of legal and science scholars, and to elected and appointed officials across the nation, VCPC engages in a host of information exchanges and collaborative partnerships.

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VCPC grounds its pedagogical goals in the law school's philosophy of the citizen lawyer. VCPC students' highly diverse interactions beyond the borders of the legal community provide the framework for their efforts in solving the complex coastal resource management issues that currently face Virginia and the nation.

I. OVERVIEW

Virginia's freshwater resources are renewable, but ultimately finite. There are substantial costs associated with the use, development, and depletion of our ground and surface water resources. The Virginia Department of Environmental Quality ("DEQ") anticipates a 30% increase in average daily water demand by 2040.[1] As water demand rises and climate patterns shift, it becomes increasingly necessary to prioritize our use of water resources and determine the legal measures we will take to prepare, and the costs and benefits of various water infrastructures. At present, more data is needed regarding our groundwater and surface water before we can develop a reasonable model by which to predict the optimal path for water use in the Commonwealth.

This paper begins by exploring the current state of water resources planning and permitting. Then, considers current water demand in Virginia, as well as future challenges. Next is an examination of management structures from other states and a discussion of potential solutions to the water scarcity issue, including wastewater purification, the Hampton Roads Sanitation District's (HRSD) Sustainable Water Initiative For Tomorrow (SWIFT) project, and desalination. The paper concludes with various next steps and policy recommendations that the Commonwealth should consider as dwindling water resources could hamper economic growth and threaten drought conditions, such as regional planning to achieve the optimal use of ground and surface water and increased funding to develop a full model that evaluates the costs and benefits of utilizing different water resources.

II. WATER RESOURCES PLANNING AND PERMITTING IN VIRGINIA

Virginia Code § 62.1-44.38:1 requires a statewide water supply planning process, purposed with ensuring safe drinking water, encouraging and protecting beneficial uses, and developing alternative water sources.[2] In order for this to be successful, Virginia requires each locality to submit a local water supply plan or participate in a regional planning unit.[3] DEQ then compiles information from all local and regional supply plans in the State in order to create Virginia's State Water Resources Plan (State Plan).[4] The State Plan addresses predicted water supply challenges that Virginia will face within the next 30-50 years.

A. Water Supply Planning

The goal of the State Plan is to coordinate drought response actions and water resources management.[5] In order to do so, the State Plan assesses beneficial uses of waters within each

[1] Va. Dept. of Envtl. Quality, *Virginia Water Resources Plan*, 45 (2015), https://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/WaterSupplyPlanning/StateWaterResourcesPlan.aspx [hereinafter DEQ State Water Resources Plan].
[2] VA. CODE ANN. § 62.1-44.38:1 (2006).
[3] 9 VA. ADMIN. CODE § 25-780-50 (2005).
[4] DEQ State Water Resources Plan, *supra* note 1, at xii.
[5] 9 VA. ADMIN. CODE § 25-780-50.

watershed within Virginia.[6] Each locality submits data to DEQ, which DEQ then analyzes to determine the water flow statistics such as flow variations in addition to withdrawals and discharges.[7] Flow alterations are discussed for ground and surface water withdrawals, point sources, water supply dams, flood control dams, and impervious area.[8] The State Plan is implemented by each locality; however, the State will provide technical assistance, guidance on compliance options, and other forms of assistance as needed.

Every 5 years, each locality must review its local plans and programs; if new information is available with regard to change to water demands, impacts, or beneficial uses, the plan must be resubmitted.[9] If there is no new information that changes the applicability of a locality's plan, each locality's plan is to be reviewed, revised, and resubmitted every 10 years from the date of the last approval.[10]

B. Groundwater Permitting

The Commonwealth has designated groundwater management areas in eastern Virginia and the Eastern Shore, in which any withdrawal of 300,000 gallons per month or more requires a permit issued by the State Water Control Board.[11] Since each withdrawer is measured separately here, subdivisions which cumulatively withdrew 300,000 or more gallons per month were exempt from permit application. However, HB358 (2018) attempts to address this loophole for subdivisions with 30+ houses with private wells by requiring developers to apply for DEQ evaluation of the impact of such a proposed development on the aquifer.[12] Conversely, SB520 (2018), which would have limited nonagricultural irrigation well withdrawals to the surficial aquifer in groundwater management areas, was defeated during the same legislative session.[13]

During the application process for groundwater withdrawal permitting, the State Water Control Board reviews hydrological data about the aquifer, an assessment of the proposed withdrawal's impact on other users, and well construction plans.[14] When groundwater sources are insufficient for all beneficial uses, the State Water Control Board must prioritize human consumption over other beneficial uses. For new or expanded permitted withdrawals, DEQ outlines the following typical requirements for application: 1) a "preapplication meeting with the DEQ Office of Water Supply staff", 2) a demonstrated need for the quantity of water to be withdrawn, 3) hydrogeologic data such as the transmissivity and storage of the aquifer, 4) an impact mitigation plan to protect pre-existing withdrawers, 5) a plan for water conservation and management, 6) an assessment of the "lowest quality water needed for the intended beneficial

[6] DEQ State Water Resources Plan, *supra* note 1.
[7] *Id.*
[8] *Id.* at 75.
[9] 9 VA. ADMIN. CODE § 25-780-50(D).
[10] 9 VA. ADMIN. CODE § 25-780-50(E).
[11] VA. CODE ANN. § 62.1-260 (1994).
[12] 2018 Va. Acts. Ch. 427, *available at* https://lis.virginia.gov/cgi-bin/legp604.exe?181+ful+HB358ER.
[13] SB 520, 2018 Legis. Sess., *available at* https://lis.virginia.gov/cgi-bin/legp604.exe?181+cab+SC10112SB0520+SBREF.
[14] 9 VA. ADMIN. CODE § 25-610-110 (2014).

use", 7) an assessment of alternative water supply sources, and 8) an application fee which varies by category of withdrawal.[15]

A completed application must also contain a completed well construction report, a topographic map showing the location of all wells, and a certification from the locality in which the withdrawal is occurring that the withdrawal complies with local ordinances, unless the locality fails to respond to a request for the certification within 45 days of receipt.[16] Applications must be completed 270 days before the requested action in question, or before a current permit expires.[17]

C. Surface Water Permitting

A Virginia Water Protection Permit is required for withdrawals of 10,000 gallons per day or more from nontidal surface waters, and 2 million gallons per day from tidal waters.[18] Agricultural withdrawals of less than one million gallons per month in nontidal waters and 60 million gallons per month from tidal waters are exempt from permitting requirements.[19] Nonconsumptive tidal withdrawals are also exempt,[20] as are firefighting and training for firefighting, hydrostatic pressure testing, and normal single-family home residential use.[21] The permitting system's capacity to limit withdrawals is hindered by allowances for "grandfathered" withdrawals prior to 1989 or 2007, depending on the permit received at the time, which do not presently exceed the withdrawal amount for which they were previously permitted.[22] As discussed in the Groundwater Permitting section above, "normal" single-family residential withdrawals are exempt from the current surface water withdrawal regulatory schema, as are "grandfathered" withdrawals. This is particularly concerning as water levels fall: During drought conditions, these withdrawals are not required to conserve water, irrespective of the volume they use. This makes surface water resources particularly susceptible to depletion during times of stress.[23] Thus, the current permitting schema is unable to limit some longstanding withdrawals.

Permit fees are not required for Agricultural withdrawals.[24] For instream flow withdrawals, issuance fees range from $10,000 to $25,000 as withdrawal amounts increase beyond 1 million gallons in a day.[25] Modification permitting fees remain constant for these withdrawals at $5000. Reservoir permit issuance fees are $25,000 or $35,000, depending on the size of the reservoir, while modification fees remain constant for reservoirs at $12,500.[26] The application form for

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[15] *Groundwater Withdrawal Permitting and Fees*, VA. DEP'T. OF ENVTL. QUALITY, http://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/WaterWithdrawalPermittingandCompliance/GroundwaterWithdrawalPermitsFees.aspx (last accessed May 7, 2018).
[16] 9 VA. ADMIN. CODE § 25-610-94 (2014).
[17] 9 VA. ADMIN. CODE § 25-610-96 (2014); *Groundwater Withdrawal Permitting and Fees*, supra note 15.
[18] 9 VA. ADMIN. CODE 25-210-310(A)(11) (2016).
[19] *Id. at* (A)(4).
[20] *Id. at* (A)(5).
[21] *Id. at* (A)(6).
[22] *Id. at* (A)(2-3).
[23] DEQ State Water Resources Plan, *supra* note 1, at 59.
[24] *Surface Water Withdrawal Permitting and Fees*, VA. DEP'T. OF ENVTL. QUALITY, https://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/WaterWithdrawalPermittingandCompliance/SurfaceWaterWithdrawalPermittingandFees.aspx (last accessed August 17, 2018).
[25] *Id.*
[26] *Id.*

surface water withdrawals contains twenty-six sections that solicit project details from applicants including the needs and uses of the withdrawal, project costs, an assessment of impacts to threatened and endangered species, shoreline stabilization structures, an assessment of alternatives, and many others.[27]

III. VIRGINIA'S WATER SUPPLY AND FUTURE OUTLOOKS

As Virginia's water supply becomes more limited due to droughts seen over the past two decades, the demand for water is projected to steadily increase.[28] However, increasing demand is not the only issue threatening Virginia's water supply; climate patterns, an ever-changing variable, also play a role in water scarcity.[29]

A. Groundwater and Surface Water Demand

Over 1.6 million citizens use private groundwater wells for residential use in Virginia.[30] Groundwater has low treatment costs, but also a slow recharge rate which is likely slower than current use rates.[31] In the 2015 Virginia Water Resources Plan, DEQ describes groundwater supplies as "oversubscribed, [and] not sustainable for the long term at current use."[32] Additionally, in the Eastern Virginia Groundwater Management Area, small, unpermitted users make 30% of withdrawals; and although recent efforts by DEQ have reduced maximum permitted use by 52.4%, reductions in permitted use alone will not remedy the depletion of the aquifer.[33] Furthermore, the insufficient groundwater in eastern Virginia cannot sustain even moderate new withdrawals, potentially preventing new industries from locating in the region.[34]

There are roughly 800 surface water withdrawals from reservoirs, streams, and spring sources reported in Virginia.[35] Surface water supplies 74% of Virginia's water use[36] and 90% of Virginia's consumptive withdrawals.[37] DEQ states "Virginia's net water withdrawal from surface water in non-tidal streams is less than 5% of the median daily streamflow."[38] However, this should not indicate surface water resources can be used without issues. By 2040, 16% of streams are predicted to see more than 5% reduction during droughts, and DEQ states "this indicates a high

[27] STANDARD JOINT PERMIT APPLICATION, *http://www.deq.virginia.gov/Portals/0/DEQ/Water/WetlandsStreams/fillable%20Standard%20JPA%20May%202017.pdf?ver=2017-05-23-162845-663* (last accessed May 7, 2018).
[28] DEQ State Water Resources Plan, *supra* note 1, at xii.
[29] *See id.* at 75.
[30] *Id.* at 45.
[31] Eastern Virginia Groundwater Management Advisory Committee, *Report to the Virginia Department of Environmental Quality and Virginia General Assembly*, 14 (2017), http://www.deq.virginia.gov/Portals/0/DEQ/Water/GroundwaterPermitting/EVGMAC/GWAC_FinalReport_8.07.17.pdf?ver=2017-08-08-092925-940 [hereinafter EVGWMAC Report 2017].
[32] DEQ State Water Resources Plan, *supra* note 1, at 45.
[33] EVGWMAC Report 2017, *supra* note 31, at 15.
[34] Joint Legislative Audit and Review Commission, *JLARC Report 486: Effectiveness of Virginia's Water Resource Planning and Management*, 5 (2016), http://jlarc.virginia.gov/pdfs/reports/Rpt486.pdf [hereinafter JLARC Report 2016].
[35] DEQ State Water Resources Plan, *supra* note 1, at 59.
[36] *Id.* at 48.
[37] JLARC Report 2016, *supra* note 34, at 2.
[38] DEQ State Water Resources Plan, *supra* note 1, at 59.

probability that new management and/or infrastructure will be required to maintain safe yields at current levels."[39]

B. Depletion and Changing Climates

As supplies of groundwater dwindle, water system-wide problems will inevitably hinder the Commonwealth. Groundwater depletion disproportionately impacts poor and rural communities,[40] since the poorer landowners have fewer means to dig deeper wells as water tables fall.[41] As groundwater is depleted, this will also promote land subsidence,[42] a problem already faced in Hampton Roads.[43] Furthermore, as water tables lower, the energy costs to pump it out of the ground increase.[44] This is particularly concerning when considering electric grid capacity: the summer months for watering crops are the same months when air conditioners are creating electricity demand as well.[45] Water quality issues become a greater concern as well, as less and less water is available to dilute pollutants and salts which find their way into the aquifer.[46] Eventually, salt-water intrusion from oceans would also grow worse as the aquifer pressure declines, further ruining the potability of the remaining groundwater.[47] The inevitable impact of substantial depletion of groundwater resources is economic.[48] Groundwater withdrawals alone are projected to provide 23% of Virginia's water demands by the year 2040.[49] As groundwater supplies dwindle, economic development in areas without ample surface water will be stifled,[50] particularly when there is insufficient groundwater in eastern Virginia to allow for new industries even with moderate withdrawals.[51] DEQ has already denied a groundwater permit renewal seeking an

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[39] *Id.* at 98.
[40] Brett Walton, *California's Dogged Drought Cutting Off Water Supplies to State's Poor,* Circle of Blue, Aug. 26, 2014, http://www.circleofblue.org/2014/world/californias-dogged-drought-cutting-water-supplies-states-poor/ (referring to California conditions). The need for deeper wells as water tables fall is a predictable outcome for any groundwater source. *See* Kurt Stephenson, *An Investigation of the Economic Impacts of Coastal Plain Aquifer Depletion and Actions That May Be Needed To Maintain Long-Term Availability and Productivity,* VA. TECH., 5 (2014), http://www.deq.virginia.gov/Portals/0/DEQ/Water/GroundwaterPermitting/VA_DEQ_GW_Impact_Final.pdf [hereinafter Stephenson Report] ("If groundwater levels drop below the well depth, that well will no longer be able to extract water. This would require a groundwater user to go without groundwater, deepen the well, or secure an alternative source, all of which would impose costs.").
[41] Walton, *supra* note 40.
[42] Tara Moran et al., *The Hidden Costs of Groundwater Overdraft,* WATER IN THE WEST, Sep. 9, 2014, http://waterinthewest.stanford.edu/groundwater/overdraft/.
[43] *See* Jack Eggleston & Jason Pope, *Land Subsidence and Relative Sea-Level Rise in the Southern Chesapeake Bay Region*, U.S. GEOLOGICAL SURV. (2013), https://pubs.usgs.gov/circ/1392/pdf/circ1392.pdf.
[44] Moran et al., *supra* note 42.
[45] *Id.*
[46] *Id.*
[47] *Id.; see* Stephenson Report, *supra* note 40 ("As water levels decline in the aquifers, the saltwater gradient tends to move inland, degrading the quality of water in the aquifer. This saltwater intrusion can make groundwater unusable for some purposes without new or additional treatment. Treatment to remove salts typically requires advanced technologies, such as reverse osmosis, which is costly.")
[48] *See generally,* Stephenson Report, *supra* note 40.
[49] DEQ State Water Resources Plan, *supra* note 1.
[50] Stephenson Report, *supra* note 40, at 16.
[51] JLARC Report 2016, *supra* note 34, at i (stating "This tenuous sustainability means that there is currently insufficient groundwater in eastern Virginia to accommodate any major, new permit requests. According to analysis

additional allocation for an existing racetrack, deeming irrigation and dust control of the track a nonbeneficial use.[52] The issue was resolved by the county building a water reclamation plant that provides irrigation water to the racetrack and two golf courses.[53] One can anticipate that these water-supply limitations on business growth and operation will only get worse as the aquifer is depleted. Therefore, depletion also has macroeconomic costs as water supplies fall below what is needed for economic development.

Due to climate shifts, future drought conditions remain uncertain; depending on the choice of model, predictions vary between more or less frequent drought conditions.[54] Furthermore, surface water reductions can substantially alter wetlands, destroying the habitats of the many flora and fauna that characterize these areas.[55] However, even when surface water supplies are available, the costs to transport, secure, and purchase water from localities with direct access to these resources can serve as a barrier to use, disincentivizing surface water withdrawals.[56]

Climate change impacts on water resource systems are fraught with uncertainty.[57] Although groundwater is renewable, it replenishes slowly, and the Commonwealth should proceed with caution to avoid overusing this resource as the state of our climate and warming trends remain in flux.[58] Climate change will impact recharge rates, and therefore depth of available groundwater.[59] Increasing climate change pressures will also likely affect our surface water levels.[60] Climate shifts

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conducted for this study, new permit requests (for example, requests by industries seeking to locate in the region) for even a moderate amount of groundwater cannot be accommodated.").

[52]Va. Coastal Zone Mgmt. Program, *Middle Peninsula: Water Reuse Study,* VA. DEP'T OF ENVTL. QUALITY, 45 (2014), http://deq.state.va.us/Portals/0/DEQ/CoastalZoneManagement/FundsInitiativesProjects/task52-13.pdf.

[53] *Id.*

[54] *See e.g.*, Chounghyun Seong et al., *An investigation into the Chesapeake Bay Watershed Hydrologic Budget under Future Climate Change Scenarios,* American Water Resources Association (2014), https://www.researchgate.net/publication/268278061_An_Investigation_into_the_Chesapeake_Bay_Watershed_Hydrologic_Budget_under_Future_Climate_Change_Scenarios; Hyunwoo Kang & Venkataramana Sridhar, *Description of future drought indices in Virginia*, 14 DATA IN BRIEF, 278-290 (2017), https://www.sciencedirect.com/science/article/pii/S235234091730344X.

[55] *See* R.T. Kingsford, *Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia*, 25 AUSTRAL ECOLOGY 109 (2000), https://onlinelibrary.wiley.com/doi/pdf/10.1046/j.14429993.2000.01036.x; DEQ State Water Resources Plan, *supra* note 1, at 79-80.

[56] *See, e.g.,* Marc Davis, *Water supply helped Virginia Beach to flourish,* VA. PILOT, Nov. 5, 2007, https://pilotonline.com/news/article_7e6596e5-bc62-5f09-aa82-c6986881bd09.html.

[57] Timothy R. Green et al., *Beneath the surface of global change: Impacts of climate change on groundwater*, University of Nebraska (2011), https://digitalcommons.unl.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1856&context=usdaarsfacpub.

[58] *Id.*

[59] Fulco Ludwig & Marcus Moench, *The Impacts of Climate Change on Water,* CLIMATE CHANGE ADAPTATION IN THE WATER SECTOR (2009).

[60] *See* Ali Ahmadalipour, Hamid Moradkhani, and Mark Svoboda, *Centennial Drought Outlook Over the CONUS using NASA-NEX Downscaled Climate Ensemble,* 37 INT'L. J. CLIMATOLOGY 2477, 2484 (2017) (concluding that more intense drought conditions in the summer months are expected over the next one hundred years for Northeastern and Southeastern U.S. due to changes in precipitation from climate change); Udall, B. and J. Overpeck, *The twenty first century Colorado River hot drought and implications for the future*, 53 WATER RESOUR. RES. 2404 (2017), https://doi.org/10.1002/2016WR019638; Selma B. Guerreiro et al., *Dry getting drier – The future of transnational river basins in Iberia*, 12 J Hydrology: Reg'l Studies 238 (2017).

are not a minor factor; in some cases worldwide, rivers can be expected to dry up completely.[61] However, as noted above, climate change in Virginia will also increase precipitation.[62] Conversely, evapotranspiration will increase due to hotter temperatures, reducing streamflow and groundwater aquifer levels.[63] The ultimate trend of these two forces is lower streamflow.[64] However, whether there will be an increase or decrease in drought frequency can vary by choice of models.[65] The more uncertainty, the greater range of possibilities the Commonwealth will need to prepare for. Ultimately, the need for more data and modelling methods is paramount to understanding this problem.[66] Although dams and reservoirs can cause unwanted environmental impacts and trigger legal challenges,[67] more reservoir infrastructure will prove necessary to adapt to impending climate change[68] by storing water to use during times of stress. Thankfully, DEQ will address climate change scenarios at the 30 and 50-year horizons in its 2019 State Water Resources Plan, which may further clarify the situation.[69]

IV. PROTECTING AND PRESERVING VIRGINIA'S WATER SUPPLY

The risk of water depletion in both groundwater and surface water sources remains a clear and present danger. Groundwater overuse can have a variety of negative effects; namely, the drying up of wells, reduction of water in streams and lakes and resultant reduced groundwater recharge rates, and land subsidence.[70] Groundwater depletion not only results in the lowering of the water table, but also creates an increase in costs for the user.[71] When the user is the State, these costs can be passed on to residents through taxes. Finding solutions to keep costs lower can also help conserve water resources. Surface water is also threatened, primarily by projected changes in daily withdrawals due to seasonal changes.[72] Additionally, when water is scarce due to droughts, average water demands represent a higher percentage of the total mean flow of surface waters.[73] There is a range of potential avenues to consider, and this paper does not and cannot exhaustively

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[61] *See, e.g.*, Lorenzo-Lacruz et al., *The impact of droughts and water management on various hydrological systems in the headwaters of the Tagus River (central Spain)*, 386 J. Hydrology, 13 (2010). Targeted research and climate modeling is necessary to determine if Virginia is at risk for similar problems.
[62] *See* Hyunwoo Kang & Venkataramana Sridhar, *Hydroclimatic variability and change in the Chesapeake Bay Watershed*, 8(2), J. WATER CLIMATE CHANGE, 278 (2016), https://iwaponline.com/jwcc/article-abstract/8/2/254/1761/Hydroclimatic-variability-and-change-in-the?redirectedFrom=fulltext.
[63] *Id.*
[64] *See id*.
[65] *See* Chounghyun Seong et al., *supra* note 54.
[66] "Due to lack of understanding of several key processes, the uncertainty associated with [groundwater] management techniques such as numerical modelling is high." Bjørn Kløve et al., *Climate change impacts on groundwater and dependent ecosystems*, 518 J. Hydrology 250 (2013), http://www.graphicnetwork.net/wp-content/uploads/2014/09/Klove_etal_2013_JoH.pdf.
[67] *See, e.g., All. to Save the Mattaponi v. U.S. Army Corps of Engineers*, 606 F. Supp. 2d 121, 126 (D.D.C. 2009).
[68] Nima Ehsani et al., *Reservoir operations under climate change: Storage capacity options to mitigate risk*, 555 J. Hydrology 435 (2017), https://www.sciencedirect.com/science/article/pii/S0022169417305991.
[69] Telephone interview with Robert Burgholzer, Surface Water Modeler, Va. Dept. of Envtl. Quality (Apr. 11, 2018).
[70] *Groundwater depletion*, U.S. GEOLOGICAL SURVEY, https://water.usgs.gov/edu/gwdepletion.html (last accessed Apr. 16, 2018).
[71] *Id*.
[72] DEQ State Water Resources Plan, *supra* note 1, at 60.
[73] *Id.* at 59.

cover all possible solutions. Instead, this section will focus on management structures and methods to replenish water supply.

A. Management Structures

One of the most important factors in whatever water supply conservation approach is chosen is cooperation amongst regions. For example, localities across the country have created water management plans at a local or regional level, and ensured that impacted stakeholders are on the same page. This level of cooperation can be instrumental in creating an effective water conservation plan. Some of these state plans, as well as other solutions, are discussed below.

1. California's Integrated Approach

One of the states in the country that generally comes to mind when one thinks of water conservation and droughts is California. The common droughts and water shortages in California are frequent focuses in news sources across the country.[74] Due to this limited water supply, the California State Water Resources Control Board (CSWRCB) has adopted more permanent changes to "use water more wisely and prepare for more frequent and persistent periods of limited water supply."[75] Pursuant to the federal Clean Water Act,[76] as well as California's Poster-Cologne Water Quality Control Act,[77] wastewater discharges to surface waters are regulated; as is stormwater, although it is regulated separately.[78]

Furthermore, California has authorized various agencies to be the exclusive local groundwater management agencies (subject to an opt-out clause) within "their respective statutory boundaries with powers to comply with [California groundwater statutes]."[79] This statutory approach not only clarifies proper water authority within statutory boundaries, but also serves as a unifier across the state for common practices. This unification and cooperation is extremely important in creating an effective water management plan.

California also uses permitting to ensure water conservation and quality. State permits contain pollutant limits, wastewater treatment monitoring requirements, and maintenance and certification requirements for facilities.[80]

In 2016, the Environmental Defense Fund (EDF) released a policy reformation recommendation paper for the California water market in which they highlighted the importance

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[74] *See, e.g.*, Dale Sasler, *Last California drought one of the worst since Columbus landed in the New World*, THE SACRAMENTO BEE (Mar. 12, 2018), http://www.sacbee.com/latest-news/article204769379.html; Jackie Ratner, *The water shortage may be coming to your neighborhood*, CNN (Mar. 5, 2018), https://www.cnn.com/2018/03/05/opinions/water-scarcity-cape-town-opinion-ratner/index.html.
[75] *See Water Conservation Portal*, CA. WATER BOARDS (2018), https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/.
[76] 33 U.S.C. §§ 1251-1387 (1972).
[77] Porter-Cologne Water Quality Control Act, 7 CAL. WATER CODE § 13000 et seq. (effective Jan. 1, 2018), https://www.waterboards.ca.gov/laws_regulations/docs/portercologne.pdf.
[78] *See Wastewater*, CA. WATER BOARDS (2018), https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/wastewater.html.
[79] 6 CAL. WATER CODE § 10723(c)(2).
[80] *See Wastewater*, *supra* note 78.

of cooperation.[81] In the press release announcing this paper, the EDF highlighted that—although California had a functioning water market—it was burdened by "patchwork regulations that discourage transfers and routinely benefit only well-capitalized water users."[82]

The cooperation recommended by the EDF included a centralized data publication location that would drive development and digitization of information, in addition to connecting exchange platforms hosted by water market management.[83] Furthermore, the EDF recommended a focus on standardizing the types of information collected, such as the quantity of water transferred in acre feet, the price of water (both in total and per acre foot), and the nature of water transferred (such as surface water destined for groundwater recharge), amongst other recommendations.[84] This standardization across the California water market would not only allow different water market managers to work collectively more efficiently, but also would create a standard that all could understand and utilize in the conservation of water in California.

While California's programs are steps in the right direction, there is still a long way to go. A recent study found that gaps in one water restoration project were "lacking standardization, and sustainable funding for the maintaining, monitoring, and data collection that is needed post-implementation."[85] Not surprisingly—and a common theme in almost all cases—funding was one of the fundamental problems faced in creating a water supply infrastructure that can handle increased demands in a manner that helps not only solve current problems, but also prevent future ones.[86]

2. North Carolina's Regulatory Approach

North Carolina's surface water regulations are quite extensive, comprising approximately 300 pages that detail everything from general practices to water management strategies for specific regions.[87] Furthermore, North Carolina has created a system by which local governments can submit local water supply plans for review and approval.[88] The submission of local water supply plans is required through North Carolina statute to ensure that plans account for reduction of long-term per capita demand of potable water, how the local community will respond to possible

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[81] *See* Scott Sellers et al., *Better Access. Healthier Environment. Prosperous Communities. Recommended Reforms for the California Water Market*, ENVTL. DEFENSE FUND (Apr. 2016), https://www.edf.org/sites/default/files/california-water-market.pdf.
[82] Press Release, Envtl. Defense Fund, EDF Recommends Policy Reforms for California Water Market (May 3, 2018) (https://www.edf.org/media/edf-recommends-policy-reforms-california-water-market).
[83] Scott Sellers et al., *supra* note 81, at 11.
[84] *Id.*
[85] Tara M. Morin, *A Case Study of Northern California: An Evaluation of Stream Restoration and the Success of Increasing California's Native Salmonid Stocks,* U. S. F. SCHOLARSHIP REPOSITORY 531, 2 (2017), available at https://repository.usfca.edu/cgi/viewcontent.cgi?article=1563&context=capstone.
[86] *See id.* at 76.
[87] 15A N.C. ADMIN. CODE §§ 02B.0101 to .0609.
[88] *See generally* 15A N.C. ADMIN. CODE 02E.0600 (North Carolina code requiring an online submission of local water system plans); *Local Water Supply Plans*, N.C. DEP'T OF ENV'T. NAT. RES., https://www.nc.gov/services/local-water-supply-plan (online portal where local governments can submit a local water plan).

drought or emergencies, and present and projected populations and development, as well as a range of other information.[89]

This requirement in North Carolina ensures that local communities are thinking about water needs, both in the long-term as well as the short term. Additionally, it ensures that the state government is aware of water demands across the state and can therefore identify areas of need or where use is heavy and utilities may be under heavier loads, requiring more frequent repair or replacement of equipment and facilities. Furthermore, the water plans are submitted to a Drought Management Advisory Council, which is granted the power to implement or change water plans in times of drought and water shortages, and engage in policy and rule making.[90]

As with California, droughts have been a problem for North Carolina. In 2007-2008, North Carolina suffered the worst drought in recorded state history.[91] In response, the Drought Management Act (DMA)[92] was signed into law in July of 2008.[93] The DMA imposed registration requirements on any person who withdraws more than 100,000 gallons of water per day from either surface or groundwater sources in North Carolina.[94] The DMA also imposed an annual requirement on the Department of Agriculture and Consumer Services (DACS) to collect information on water usage by people withdrawing more than 10,000 gallons of water per day from surface or groundwater sources.[95] This requirement also included the obligation that DACS make recommendations to the Department of Environment and Natural Resources about modifications to be made to water-usage surveys, including the gallons-per-day threshold to adapt to available water resources.[96]

Statutory requirements such as the DMA in North Carolina not only help ensure that general water conservation requirements are being followed, but also help the state adapt to changes. If the reports find that water sources such as aquifers are being replenished, requirements can be adapted. Conversely, if sources are still being depleted, requirements can be stiffened to allow these sources time to replenish without suffering from over-withdrawal.

North Carolina is also actively implementing and conducting a range of watershed initiatives to "help improve water resources in North Carolina benefitting all citizens."[97] These initiatives range from cost share dollars targeted to specific watersheds, to flood prevention methods.[98] For example, "PL-566"[99] is a watershed initiative covering both protection and flood

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[89] *See* N.C. GEN. STAT. § 143-355(1) (2012).
[90] *See* N.C. GEN. STAT. §§ 143-355 to -355.7.
[91] SAVE WATER NC, http://www.savewaternc.org/ (last visited Apr. 19, 2018).
[92] 2007 N.C. Sess. Laws 2008-143, HB 2499, https://www.ncleg.net/EnactedLegislation/SessionLaws/PDF/2007-2008/SL2008-143.pdf.
[93] SAVE WATER NC, *supra* note 91.
[94] N.C. GEN. STAT. § 143-215.22H.
[95] N.C. GEN. STAT. § 106-24(b).
[96] *Id.*
[97] *Watershed Initiatives*, N.C. DEP'T AGRIC. CONSUMER SERV., http://www.ncagr.gov/SWC/watershed/index.html (last visited Apr. 18, 2018).
[98] *Id.*
[99] *See Watershed Initiatives – PL-566 Watershed Protection & Flood Prevention,* N.C. DEP'T AGRIC. CONSUMER SERV., http://www.ncagr.gov/SWC/watershed/PL566.html (last visited Apr. 18, 2018).

prevention.[100] PL-566 projects must be approved by the North Carolina Soil and Water Conservation Commission,[101] again ensuring that climate change, water sources, and other factors impacting water supply can be continuously monitored and programs can be adequately adapted.

Furthermore, North Carolina has worked to develop water conservation awareness among citizens. For example, in 2008, the Town of Cary began offering $150 rebates to water customers who replaced their older toilets with high efficiency toilets that use 75% to 80% less water.[102] The two main focus areas of this program are to "(1) reduc[e] per capita water consumption, and (2) manag[e] the peak demands that occur during the hottest, driest times of the year."[103]

Other cities in North Carolina have a focus on encouraging water conservation in the home. For example, Charlotte offers customers a kit to conduct their own home water use audit; Chapel Hill adopted year-round water use restrictions; and Raleigh took a multifaceted approach to water conservation, including a showerhead and aerators "swap-out" program and a toilet rebate program.[104]

Additionally, the North Carolina Department of Environmental Quality (NCDEQ) has several programs in place with the goal of eliminating water waste. For example, the State Wastewater and Drinking Water Reserve Programs provide funding for planning, designing, and constructing "critical water infrastructure."[105] Other projects provide low interest loans to local governments to address water and wastewater infrastructure needs, allowing governments to conserve water effectively when they otherwise would not have the funding to do so.[106]

3. Georgia's Regional Coordination Approach

Georgia is another state actively planning for water conservation. The Environmental Protection Division (EPD) regulates the state's water conservation projects[107] and the Georgia Code extensively covers conservation, natural resources, and—more specifically—water resources.[108]

The 2010 Georgia Water Stewardship Act (GWSA),[109] enacted by the state legislature, is designed to develop "new fresh water supply sources while also reaffirming *the imminent need to*

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[100] *Id.*
[101] *See id.*
[102] *New Program Encourages Cary Citizens to Stop Flushing Water and Money Down the Commode,* TOWN OF CARY (June 3, 2008), http://www.townofcary.org/Home/Components/News/News/7105/.
[103] *Id.*
[104] For more information about these programs, as well as other North Carolina programs encouraging water conservation in the home, *see In Our Cities*, SAVE WATER NC (2017), http://www.savewaternc.org/citieshome.php.
[105] *North Carolina Water and Wastewater Funding Sources,* ENVTL. FINANCE CENTER NETWORK (May 2016), https://efc.sog.unc.edu/sites/www.efc.sog.unc.edu/files/2017/NC-Water-Wastewater-Funds-2016.pdf.
[106] *Id.*
[107] *Water Conservation*, ENVTL. PROT. DIVISION, GA. DEP'T OF NAT. RES., https://epd.georgia.gov/water-conservation (last visited Apr. 17, 2018).
[108] *See* GA. CODE ANN. § 12-5-3 to -586.
[109] 2009-2010 Ga. Laws SB 370.

create a culture of water conservation in the state of Georgia."[110] This Act brings together three key actors, highlighting the importance of regional and statewide cooperation in water conservation. These three actors—local governments, public water systems, and state agencies—are assigned mandatory tasks to further this goal of creating a water conservation culture.[111]

- Local governments were required to adopt or amend local ordinances to restrict outdoor water use for landscapes, as well as update plumbing codes to focus on high-efficiency fixtures and sub-meters to track water usage by a specific deadline.[112]

- Public water systems were required to complete annual water loss audits for systems serving 10,000 or more people by 2012, and systems servicing 3,000 or more people by 2013, as well as the submission of annual water loss audits within 60 days of audit.[113] This emphasis on high-service water systems demonstrates Georgia's goal to identify the largest water loss problems, allowing more impactful action to take precedent over the less impactful.

- Finally, state agencies were required to collaborate with "agencies that deal with water to enhance programs and incentives for voluntary water conservation,"[114] as well as to submit annual reports to the General Assembly summarizing programmatic changes that encourage conservation.[115]

The GWSA not only focused on regional cooperation, drawing in the three main actors involved with water supply, but also brought them together in a way that could provide a direct impact. Local governments were assigned the small, immediate tasks as it would be easier for them to make changes applicable to their region. Public water systems were tasked with identifying water loss systems on a scale that allowed for rapid action. State agencies were tasked with the high-level actions that could shape the future of Georgia's water supply.

The GWSA was arguably very successful. In 2017, the EPD eased outdoor watering limits in 56 counties across the state.[116] Furthermore, between 2000 and 2015, per capita water use dropped more than 30% in Georgia.[117] Director of the Metropolitan North Georgia Water District, Katherine Zitsch, said that the drop is a testament to the impact the GWSA has had since its adoption in 2010.[118] Furthermore, water use in metro-Atlanta is now projected to be 25% lower in

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[110] *The 2010 Georgia Water Stewardship Act,* THE UNIV. OF GA., http://extension.uga.edu/publications/detail.html?number=C995&title=The%202010%20Georgia%20Water%20Stewardship%20Act (emphasis in original) (Apr. 2014).
[111] *See id.*
[112] *Id.*
[113] *Id.*
[114] *Id.*
[115] *Id.*
[116] *EPD lifts outdoor watering restrictions in Forsyth County: Among 12 counties reduced to lowest drought response level*, FORSYTH CTY. NEWS (Sept. 9, 2017), https://www.forsythnews.com/local/epd-lifts-outdoor-watering-restrictions-forsyth-county/.
[117] Molly Samuel, *Personal Water Use in Atlanta Drops Thanks to Conservation*, WABE (Aug. 27, 2015), https://www.wabe.org/personal-water-use-atlanta-drops-thanks-conservation/.
[118] *Id.*

2050 than the past projection (in 2009) forecasted.[119] Clearly, the GWSA has been widely successful in reducing water usage in the state, creating the culture of water conservation the General Assembly wanted.

Georgia has also targeted individuals in attempting to further conserve water. In the metro-Atlanta area, a "toilet rebate program" began in 2008.[120] This program allowed two toilet rebates per property, encouraging residents to replace old, inefficient toilets with "low-flow WaterSense-labeled models."[121] To date, over 125,000 toilets have been replaced, resulting in a savings of nearly 2.4 million gallons of water per day.[122]

B. Replenishing Water Supply

1. Wastewater Purification

Wastewater purification and groundwater injection are two feasible solutions in the battle against depletion of available water supplies, as well as combating future supply issues. The National Institute for Standards and Technology (NIST) released a 2010 paper with comments outlining the areas of "critical national need" to ensure an adequate water supply moving forward.[123] NIST specifically noted that advanced technologies for better managing water quality is a national and critical need because every citizen requires clean water.[124] The advancement of wastewater technologies can help further this goal. However, this paper also discusses some of the more traditional methods of wastewater treatment, as they are still widely used and a helpful background to advanced techniques.

Purification of wastewater in Virginia can help the State reach its Chesapeake Bay pollution reduction goals while also increasing the supply of available water.[125] By 2015, there were 402 significant municipal wastewater facilities, and approximately 81 significant industrial wastewater facilities working to reduce wastewater loads in the Bay by 11 million pounds of nitrogen and 100,000 pounds of phosphorus.[126] These wastewater facilities were improved under a permitting program created in 2005 with the goal of limiting the amount of nitrogen and phosphorus discharged into the Bay.[127] Combined, the facilities cover approximately 75% of the flow from significant wastewater facilities into the watershed—an astounding 2.3 billion gallons of water per day.[128]

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[119] *Id.; Conserve Our Water*, NORTH GA. WATER, http://northgeorgiawater.org/conserve-our-water/ (last visited Apr. 15, 2018).
[120] *See Conserve Our Water, supra* note 119.
[121] *Id.*
[122] *Id.*
[123] *See* NAT'L INST. OF STANDARDS & TECH., WATER: NEW TECHNOLOGIES FOR MANAGING AND ENSURING FUTURE WATER AVAILABILITY (2010).
[124] *See id.* at 2.
[125] *See generally Progress on Reducing Pollution from Wastewater Facilities*, ENVTL. PROT. AGENCY, https://www3.epa.gov/reg3wapd/pdf/pdf_npdes/WastewaterProgress.pdf (last accessed Apr. 19, 2018).
[126] *Id.*
[127] *Id.*
[128] *Id.*

In 2007, Virginia had three facilities with capacity ranges from 42 mgd to 67 mgd utilizing a variety of advanced phosphorus treatment technologies.[129] These facilities use chemical (high lime)[130] and tertiary filtration,[131] chemical addition, and biological nutrient removal[132] as part of these advanced processes.[133] Advanced wastewater treatment—primarily a tertiary treatment—can be used to reduce undesired chemicals in wastewater in greater quantities when compared to more traditional wastewater treatment methods.[134] The growing trend of advanced water treatment in Virginia is demonstrated by emerging projects such as the Sustainable Water Initiative for Tomorrow (SWIFT) project discussed in depth below.

These wastewater treatment plants in Virginia are governed by the Water Reclamation and Reuse Regulations,[135] requiring permits and compliance with Virginia Pollutant Discharge Elimination System (VPDES) permit standards.[136] Currently, the DEQ administers two existing sources of funding for water reclamation and reuse projects: the Virginia Clean Water Revolving Loan Fund (VCWRLF) and the Water Quality Improvement Fund (WQIF).[137] It is worth noting that privately-owned or industrial facilities are ineligible for funding from either the VCWRLF or the WQIF.[138]

In Virginia, the legislature formed the Eastern Virginia Groundwater Management Advisory Committee (EVGMAC) to assist the State Water Commission and the DEQ in "developing, revising, and implementing a management strategy for groundwater" in eastern Virginia.[139] In a meeting of the Committee in late 2016, the group noted the five main benefits to purified wastewater being injected into the aquifer:

1. The potential to reduce nutrient loading to surface water;
2. The potential to reduce land subsidence;
3. The utilization of natural structures for distribution and storage;

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[129] ENVTL. PROTECTION AGENCY, EPA 910-R-07-002, ADVANCED WASTEWATER TREATMENT TO ACHIEVE LOW CONCENTRATION OF PHOSPHORUS, at 8 (Apr. 2007), https://nepis.epa.gov/Exe/ZyPDF.cgi/P1004JC4.PDF?Dockey=P1004JC4.PDF [hereinafter EPA ADVANCED WASTEWATER TREATMENT].
[130] The high lime treatment process is a chemical treatment that reliably produces high quality reclaimed wastewater, a process originally developed around 1972. While it used to be one of the best advanced wastewater treatment processes around, technological advances have rendered it outdated.
[131] The chemical addition to wastewater followed by tertiary filtration is extremely effective at reducing total phosphorus concentration levels. These levels are consistently near or below 0.01 mg/l. For more information, *see* EPA ADVANCED WASTEWATER TREATMENT, *supra* note 129, at 3.
[132] This advanced process includes removing nutrients and can be used to reduce the current cost of chemicals used in the removal of phosphorus from wastewater. However, this method is not the most effective, only producing phosphorus levels below the 0.11 mg/l limit at times. For more information, *see id.* at 32.
[133] *See id.* at 8.
[134] *See* J. Paul Guyer, *Introduction to Advanced Wastewater Treatment*, at 4 (2011), https://www.cedengineering.com/userfiles/Advanced%20Wastewater%20Treatment.pdf.
[135] *See generally* 9 VA. ADMIN. CODE § 25-740-40.
[136] *Water Reclamation and Reuse*, VA. DEP'T OF ENVTL. QUALITY, http://www.deq.virginia.gov/Programs/Water/LandApplicationBeneficialReuse/WaterReclamationReuse.aspx (last accessed Apr. 15, 2018).
[137] *Water Reclamation and Reuse*, *supra* note 136.
[138] *Id.*
[139] *Eastern Virginia Groundwater Management Advisory Committee*, VA. DEP'T OF ENVTL. QUALITY, http://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/EasternVirginiaGroundwaterManagementAdvisoryCommittee.aspx (last accessed May 5, 2018).

4. The readily-available nature of the source; and
5. The potential to recharge underground aquifers.[140]

However, there are also risks associated with wastewater purification systems.[141] Pipeline failure can discharge raw sewage into houses, city streets, and receiving waters. This failure cannot only result in environmental contamination, but serious public health issues as well.[142] According to one EPA report, centrifugal pumps (which are most commonly used for treating wastewater) are "complex facilities that contain a significant number of equipment and auxiliary systems" and are therefore at higher risk of failure and demonstrate a decrease in reliability.[143]

In Virginia, the design, construction, and operation of sewerage systems and treatment works serving non-residential sewage sources (and more than one residence) are governed by the Sewage Collection and Treatment Regulations.[144] The EVGMAC meeting, discussed briefly above, also mentioned some of the problems associated with wastewater purification as a source of drinking water. These not only included the necessity to recover costs and the actual feasibility of public acceptance, but they also noted the high costs associated with this type of water purification.[145] The EVGMAC drew attention to the fact that a pilot study, risk analysis, and governmental approval are necessary prior to the implementation (or use) of wastewater purification in Virginia.[146] However, wastewater purification can easily be a useful tool in ensuring that water is recycled into the water supply, helping create water sources that would otherwise be unavailable; it just must be ensured that the wastewater purification meets government standards.

In addition to the above-stated potential wastewater solutions in Virginia, there are requirements and limitations on water withdrawals to help reduce the rate at which water is being pulled from the aquifer. The Virginia Administrative Code requires any application for a permit to initiate a new withdrawal or an expansion of a current withdrawal in a groundwater management area to submit a water conservation and management plan.[147] Helpfully, the General Assembly included the specific information that must be submitted in the plans, dependent on the type of water use.[148]

For example, municipal and nonmunicipal public water supplies should, where practicable, require the use of water-saving equipment and procedures, include a water-loss reduction program,

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[140] December 13, 2016 Draft Meeting Notes, Eastern Va. Groundwater Mgmt. Advisory Comm., VA. DEP'T OF ENVTL. QUALITY http://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/EasternVirginiaGroundwaterManagementAdvisoryCommittee/WorkGroup1AlternativeSourcesofSupply.aspx.

[141] These risks are present in groundwater injection, but they are not particular to groundwater injection. Many of these risks are present any time wastewater is treated.

[142] *Water and Wastewater Systems*, DISASTER RESILIENCE FRAMEWORK, NAT'L INST. STANDARDS TECH., at 9 (Feb. 11, 2015), https://www.nist.gov/sites/default/files/documents/el/building_materials/resilience/Chapter9_75-_11Feb2015-2.pdf.

[143] *Wastewater Tech. Fact Sheet: In-Plant Pump Stations*, ENVTL. PROT. AGENCY, at 4 (Sept. 2000), https://www3.epa.gov/npdes/pubs/in-plant_pump_station.pdf.

[144] *See generally* 9 VA. ADMIN CODE §§ 25-790-10 to -1000.

[145] December 13, 2016 Draft Meeting Notes, *supra* note 140.

[146] *Id.*

[147] 9 VA. ADMIN. CODE § 25-610-100(a).

[148] *Id.* at (b).

a water-use education program, an evaluation of water reuse options, and requirements for "mandatory water-use reductions during water shortage emergencies declared by the local governing body or water authority consistent with § 15.2-923 and 15.2-924 of the Code of Virginia."[149]

Virginia has recognized a need to not only reduce the rate at which water is withdrawn from the aquifers, but also a need to ensure that it is replenished. The proposed HRSD SWIFT project, statutory and regulatory requirements for groundwater withdrawals, and the exploration of alternatives such as desalination are all productive steps in the right direction.

a. Case Study: Water Purification in the Hampton Roads Region

HRSD's SWIFT groundwater injection project aims to "further protect the region's environment, enhance the sustainability of the region's long-term groundwater supply and help address environmental pressures such as Chesapeake Bay restoration, sea level rise and saltwater intrusion."[150] The SWIFT project is built off the idea of cleaning wastewater and then injecting it below ground, aiding in the battle against sea level rise and land subsidence, while also reducing groundwater scarcity and replenishing the aquifer so that it remains a viable water source.[151] In the Hampton Roads region, land subsidence stemming from withdrawals of the Potomac Aquifer have been noted as the single greatest contributor to the sea level rise problem.[152]

Specifically, the SWIFT project will provide carbon-based advanced water treatment to over 100 million gallons per day (mgd) of secondary effluent; a goal that seems feasible after the successful initial test which concluded at the end of 2016.[153] Following this test, HRSD elected to construct a 1 mgd Research Center, instead of advancing directly to full-scale, to demonstrate the treatment process will produce water compliant with drinking water standards.[154] Ground broke on this facility in April 2017, and the facility first went online April 16, 2018 (although it is not expected to "officially open" until May 2018).[155]

As mentioned, the SWIFT facility aims to process 1 mgd in the early phase of the process. However, as initial water quality tests wind down, the SWIFT program hopes to ramp up the amount of water injection.[156] As this proceeds, HRSD will collect data produced from the facility, as well as from various monitoring wells reaching the aquifer, for the next twelve to eighteen months.[157] After the installation is fully online, SWIFT hopes to combine larger plants in the

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[149] *Id.* a (b)(1)(a)-(e).
[150] *See generally* SUSTAINABLE WATER INITIATIVE FOR TOMORROW, http://swiftva.com/ (last visited Apr. 19, 2018).
[151] *Id.*; Tyler Nading et al., *A 'Swift' Approach to Managed Aquifer Recharge*, WATER ONLINE (Jan. 24, 2018), https://www.wateronline.com/doc/a-swift-approach-to-managed-aquifer-recharge-0001.
[152] Dave Mayfield, *In using wastewater to fight sea level rise, will beer be an additional benefit?*, THE VA. PILOT (Jan. 28, 2018), https://pilotonline.com/news/local/environment/article_a5fc3267-08c6-5f90-bd41-67b4868de4ed.html.
[153] Tyler Nading et al., *supra* note 151.
[154] *Id.*
[155] Telephone Interview with Dr. Charles B. Bott, Director of Water Technology and Research, Hampton Roads Sanitation District (April 16, 2018).
[156] *Id.*
[157] *Id.*

injection process with a full build-out completed by 2030, injecting 100-120 mgd back into the aquifer.[158]

However, SWIFT has recently faced a setback with unknown ramifications. HB 771 (2018), which was set to provide funding for a monitoring committee, recently failed in the Virginia legislature.[159] HRSD has two options in place as fallbacks: (1) work with the National Water Research Institute for an independent review panel, or (2) move ahead independently from the legislature through other means to fund the monitoring facility.[160] Additionally, HRSD aims to reintroduce the bill next year with hopes to secure the funding required for the monitoring facility.[161] Once the SWIFT program is fully implemented, it could be extremely effective in aiding to replenish and maintain the groundwater supply in Virginia.

2. Desalination

Desalination, the process of extracting salts and minerals from saltwater to produce water suitable for human consumption and/or irrigation, is another possible solution to the risk of depletion of water resources.[162] By 2025, the United Nations expects 14% of the world's population to face a water scarcity crisis; and currently 1% of the world's population is dependent on desalinated water to meet daily needs.[163] Due to increasing water scarcity, the desalination industry should be looking at a very strong future.

In Virginia, a 2004 study was conducted on "desalination issues as part of a strategy to meet the Commonwealth's future drinking water needs."[164] This study, mandated by the General Assembly, found that a significant need for desalination exists but noted that desalination cannot be a stand-alone measure to meet the increasing demand for water in the Commonwealth.[165] While the data available was inconclusive, the report was able to make the recommendation that desalination was unsatisfactory for a stand-alone measure to increase water supply because of high costs.[166] Until advancements in technologies are able to reduce the costs of desalination, it cannot be considered a stand-alone measure.[167] The study recommended desalination as part of an overall water supply management program, utilizing all available sources of water for all uses of water.[168] While the study noted four desalination plants that were currently in use at the time of publication,

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[158] *Id.*
[159] HB 771, 2018 Legis. Sess., https://lis.virginia.gov/cgi-bin/legp604.exe?181+sum+HB771.
[160] Telephone Interview with Dr. Charles B. Bott, *supra* note 155.
[161] *Id.*
[162] *See Water Desalination Processes*, AM. MEMBRANE TECH. ASS'N, https://www.amtaorg.com/Water_Desalination_Processes.html (last accessed Apr. 17, 2018).
[163] *See Desalination industry enjoys growth spurt as scarcity starts to bite*, GLOBAL WATER INTEL, https://www.globalwaterintel.com/desalination-industry-enjoys-growth-spurt-scarcity-starts-bite/ (last accessed Apr. 16, 2018).
[164] Tamim Younos, *The Feasibility of Using Desalination to Supplement Drinking Water Supplies in Eastern Virginia*, VA. POLYTECHNIC INSTITUTE, at v, ix (2004), https://vtechworks.lib.vt.edu/bitstream/handle/10919/49471/VWRRC_sr200425.pdf.
[165] *Id.*
[166] *See id.* at x.
[167] *See Id.*
[168] *Id.*

the demand for water in Virginia has increased, and a proposal began being discussed in 2016 for a new desalination plant in James City County.[169]

Furthermore, the salinity of brackish surface water near coasts can change depending on circumstances such as tides, freshwater entering the system from rain or rivers, and the rate of evaporation.[170] Additional complications that can arise from the desalination process are the proximity to populated areas (as the plants often produce noise and air pollution), as well as environmental impacts (such as the possibility of chemical spills).[171]

It is also important to note the waste disposal methods used by desalination operations. As of 2004, approximately 48% of all desalination facilities in the U.S. disposed of waste in surface waters.[172] Additional disposal methods include deep well injection, land application (such as spray irrigation), evaporation ponds, zero liquid discharge,[173] submerged disposal, and disposal to wastewater treatment plants.[174] The surface water salt disposal method is the most common.[175] Surface water disposal discharges a high salinity plume into the receiving body of water.[176] This plume, without proper dilution, can extend for hundreds of meters—beyond the pre-determined mixing zone—and substantially harm the ecosystem along the way.[177] The harm to the ecosystem can result in a range of problems such as diminished water quality or dehydration of the system—although there are mitigation methods in place to help reduce the negative impact of desalination.[178]

One innovative disposal of salt currently gaining traction in Nevada and California is the usage of salt in concentrated solar power (CSP) plants, where the salt is heated to over 1,000 degrees Fahrenheit to make steam to run a turbine for energy.[179] These systems create up to 3.6 million gallons of molten salt, which represents 1,100 megawatt hours of storage (or ten times more than the largest lithium-ion batteries installed to store renewable power).[180] The prices of these systems are also rapidly decreasing—from $0.13/kWh in 2009 to less than $0.05/kWh in 2017.[181]

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[169] Jack Jacobs, *JCSA reviewed sites across three rivers for treatment plant*, VA. GAZETTE (Aug. 6, 2016), http://www.vagazette.com/news/va-vg-rivers-comparison-20160806-story.html.
[170] Tamim Younos, *supra* note 164, at 2.
[171] *Id.* at 16.
[172] *Id.* at 20.
[173] Zero liquid discharge is a water treatment process in which all of the wastewater is recycled, leaving "zero liquid discharge" at the end of the process. For more information, *see generally Zero Liquid Discharge*, AQUATECH, https://aquatech.com/solutions/zero-liquid-discharge/ (last visited May 4, 2018).
[174] Tamim Younos, *supra* note 164, at 21-25.
[175] For a more in-depth look at the other disposal methods, as well as their drawbacks, *see id.*
[176] Tamim Younos, *supra* note 164, at 21.
[177] *Id.*
[178] For a list of the environmental concerns resulting from raw water, pretreatment, or the concentrated salinity, as well as the mitigating factors, *see id.* at 22.
[179] *See* Robert Dieterich, *24-Hour Solar Energy: Molten Salt Makes It Possible, and Prices are Falling Fast*, INSIDE CLIMATE NEWS (Jan. 16, 2018), https://insideclimatenews.org/news/16012018/csp-concentrated-solar-molten-salt-storage-24-hour-renewable-energy-crescent-dunes-nevada.
[180] *See id.*
[181] *See id.*

California is in the process of exploring wastewater desalination options. The California Department of Water Resources recently awarded $34 million in grants to eight different desalination projects spread out across the state.[182] While six of these eight projects focus on ocean desalination, two of them focus specifically on "inland brackish desalination."[183] However, this brackish desalination can be quite expensive, ranging from $800 for an acre-foot of water up to $3,000.[184] California is also burdened by a reduction in desalination projects across the state. The city of Oceanside ceased pursuit of desalination (adding that they will not consider desalination as a future potential solution for at least another fifteen years), and the Doheny Ocean Desalination Project proposal was lowered to a capacity of four to five million gallons per day and lost all but one of the developers on the project.[185] Much of the reduction or abandonment of projects is due in large part to funding.[186]

While desalination is a potential—and growing—solution to water supply problems, it is unlikely that it will become a sole solution. The demands that exist are currently too high to be met by desalination alone. Furthermore, there are impacts that may actually harm water supplies and surrounding ecosystems. Perhaps most importantly—and restricting—is the prohibitively high cost of desalination.[187] Until the capacity can improve and technology can mitigate some of these concerns, desalination will remain part, but not all of, the answer.

V. POLICY RECOMMENDATIONS

Virginia has already taken active steps in combatting depletion and meeting increasing demands for water. Additionally, the SWIFT program proposed for the Hampton Roads region shows promise in not only restoring water in the aquifer, but also identifying areas in which improvements can be made (such as determining the ideal injection rate and using extensometers to track and account for land subsidence) to ensure the aquifer remains a viable resource for future generations. However, there are additional steps that Virginia can take to further this goal. Many of the policies below which alter planning can be harnessed to water supply-increasing or demand-decreasing policies.

A. Restructure Water Supply Planning in Virginia

Successful regional cooperation could give Virginia the cohesiveness necessary to fully understand and address the challenges associated with ensuring sufficient water supply for future

[182] *See* Ian Evans, *Desalinated Water in California Doesn't Have to Come From the Ocean*, NEWS DEEPLY (Mar. 20, 2018), https://www.newsdeeply.com/water/community/2018/03/20/desalinated-water-in-california-doesnt-have-to-come-from-the-ocean.
[183] *Id.*
[184] *Id.*
[185] *Existing and Proposed Seawater Desalination Plants in California*, PACIFIC INSTITUTE (May 2016), http://pacinst.org/publication/key-issues-in-seawater-desalination-proposed-facilities/.
[186] *See generally* Heather Cooley & Newsha Ajami, *Key Issues in Seawater Desalination in California: Costs and Financing*, PACIFIC INSTITUTE (Nov. 27, 2012), http://pacinst.org/publication/costs-and-financing-of-seawater-desalination-in-california/ (desalination remains among the most expensive water-supply options available, and the inconsistencies among cost-estimates make it difficult to project actual project costs).
[187] *See id.*

generations. Additionally, increased funding would provide the backing for such regional planning to be as effective as possible, through the use of accurate and up-to-date modeling.

1. Mandatory Regional Planning

Implementing a statewide program similar to the GWSA can not only identify areas of limited water supply across the state, but also allow regions to tackle the problem in a way that is most impactful by statutorily mandating the cooperation of local governments, public water systems, and state agencies and legally defining each of their roles. The needs of eastern Virginia are quite different from those of the western portion of the state, as are supply sources.[188] By implementing a state-wide approach to not only identifying local needs but planning for the future, Virginia can implement a host of water conservation and use policies while maintaining localities' voice in the process. This, in turn, promotes water supply planning policies that are suitable for the varying specific needs of local areas. A mandatory approach is in line with the recommendations of the 2016 Joint Legislative Audit and Review Commission (JLARC) report, *Effectiveness of Virginia's Water Resource Planning and Management*.[189] Additionally, in 2008, the Governor's Commission on Climate Change, established via Executive Order 59 (2007) by then-Governor Timothy M. Kaine, recommended that the State Water Control Board should amend the water supply planning regulation to require that localities or regional planning units assess the potential impacts of climate change on existing or proposed water supplies[190] This year, the General Assembly adopted SB211, authorizing a locality to show in its comprehensive plan its long-range recommendations for groundwater and surface water availability, quality and sustainability.[191] However, HB1185, which would have required regional, coordinated water resource planning, failed.[192]

2. Incentivize Regional Planning

To create a softer approach to regional water planning cooperation than simply mandating it, the State could implement an incentive structure that promotes regional cooperation by reducing water-related permitting fees for localities with a regional water supply plan. This can be coupled with increasing permit fees, as mentioned in Section V(B) below, but keeping the original, lower permit fee for localities which engage in regional cooperation. Creating incentives for regional cooperation is in line with the recommendations of the 2017 Eastern Virginia Groundwater Management Advisory Committee (EVGMAC) report to the DEQ and the Virginia General Assembly.[193]

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[188] For instance, the August Low Flow, which impacts aquatic ecosystems, will likely impact the northern and eastern portions of the State most drastically, while the western portion of the State will have only small decreases in flow. DEQ State Water Resources Plan, *supra* note 1, at 84.

[189] JLARC Report 2016, *supra* note 34, at 34.

[190] Preston Bryant, Jr., *Governor's Commission on Climate Change: A Final Report: A Climate Change Action Plan*, 39 (December 15, 2008), http://www.sealevelrisevirginia.net/docs/homepage/CCC_Final_Report-Final_12152008.pdf.

[191] 2018 Va. Acts. Ch. 420, *available at* https://lis.virginia.gov/cgi-bin/legp604.exe?181+ful+CHAP0420.

[192] *See* https://lis.virginia.gov/cgi-bin/legp604.exe?181+sum+HB1185.

[193] *See* Eastern Virginia Groundwater Management Advisory Committee, *Report to the Virginia Department of Environmental Quality and Virginia General Assembly*, 7 (2017),

The rivers and groundwater aquifers themselves are regional structures. Infrastructure projects which reduce the burden on these resources could benefit the whole region; therefore it is natural that planning and funding these projects should also flow from a regional effort. Reservoirs can be designed to serve multiple localities and reclamation projects like SWIFT can revitalize the aquifer for the enjoyment of all the localities that use it. The State can promote regional infrastructure by offering reduced permitting fees, directed financing for regional infrastructure, or establishing a fund that provides assistance with regional infrastructure. From the perspective of many state water suppliers, funding, or rather the lack thereof, is one of the greatest barriers to pursuing their ideal water supply projects.[194]

3. Groundwater vs. Surface Water Use

Groundwater is a slowly replenishable, but easily overtaxed resource. The costs, both economic and environmental, of depleting the reservoir are extensive. Current regulations require that a permit application for a new or expanded withdrawal, or reapplication for a current withdrawal within a groundwater management area must include, among other things, "information on surface water and groundwater conjunctive use systems"[195] and an "alternatives analysis that evaluates sources of water supply other than groundwater[.]"[196] Additionally, when issuing groundwater withdrawal permits of this nature, the State Water Control Board must consider whether "[t]he applicant [has] demonstrate[d] that no other sources of water supply . . . are practicable."[197] "Practicable" is further defined as "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes."[198] Virginia could consider modifying the definition of "practicable" to provide further clarification. For example, does consideration of cost include only those costs associated with implementation of the project, or does it also include costs associated with the overall sustainability of the aquifer? Additionally, Virginia could consider making other changes to regulatory language to indicate a clear preference for the use of surface water when feasible. This would mean that only those without reasonable means of accessing surface water would be using the groundwater aquifers, freeing up space for development in areas that truly must rely on the aquifer to access adequate water. Even for non-permitted uses such as watering lawns and washing cars, localities could be motivated, incentivized, or required to reduce the reliance on the groundwater aquifer generally. Incentivizing surface water use is in line with the recommendations of the 2017 Eastern Virginia Groundwater Management Advisory Committee (EVGMAC) report.[199]

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http://www.deq.virginia.gov/Portals/0/DEQ/Water/GroundwaterPermitting/EVGMAC/GWAC_FinalReport_8.07.17.pdf?ver=2017-08-08-092925-940.

[194] JLARC Report 2016, *supra* note 34, at 60.

[195] 9 VA. ADMIN. CODE § 25-610-94(2)(g); *see* 9 VA. ADMIN. CODE § 25-610-104 for additional detail regarding surface water and groundwater conjunctive use systems.

[196] 9 VA. ADMIN. CODE § 25-610-94(2)(j); *see* VA. ADMIN. CODE § 25-610-102(C)-(E) for additional detail regarding alternative analysis.

[197] 9 VA. ADMIN. CODE § 25-610-110(D)(3)(a).

[198] 9 VA. ADMIN. CODE § 25-610-10.

[199] *Id.* at 30.

B. Increased Funding

Another overarching theme of note is funding. A great of deal of uncertainty exists in our predictions of future water supplies. Uncertainty creates a need for more protective infrastructure, such as reservoirs or reclamation projects. Ultimately, the cost of conducting studies is far less than the cost of building reservoirs. By focusing on accuracy and robust analyses now, we can avoid the future costs of building reservoirs "just in case."

Data and analytics can create clarity in water supply planning, but it does not come without cost. It has been estimated that updating estimation methods for unpermitted use could cost DEQ $200,000, for which the United States Geological Survey (USGS) may be able to contribute 30%.[200] Operating and maintaining extensometers in Suffolk and Franklin would cost $40,000 per year.[201] Installing a new extensometer near West Point to monitor land subsidence would cost $1.3 million the first year and $30,000 each year afterward.[202] Implementing a network to monitor saltwater intrusion per USGS strategies would cost $2.5745 million per year for the first 10 years, and $1.35 million each year afterward.[203] Although these costs may seem substantial, each must be weighed against the risk it mitigates: the permanent loss of groundwater aquifer capacity and/or quality.[204] Since agricultural users do not pay groundwater permitting fees, there is a gap between the work DEQ must perform, and the work for which DEQ is compensated. This is particularly problematic for agricultural activities like concentrated animal feeding operations that are known for potentially causing water contamination.[205] In order to protect water resources, DEQ's analysis of water supply needs to be thorough, and in order to promote economic growth in Virginia, DEQ's analysis needs to move swiftly. Both of these considerations are supported by increased funding to DEQ to invest in permitting analysis, and capturing those funds from permit fees reduces any political backlash caused by tax increases.

The Commonwealth should fund DEQ assessments of groundwater resources to determine an accurate, sustainable withdrawal rate, and provide authority and discretion for DEQ to establish a buffer to mitigate against uncertain future drought conditions, and the increasing demand for water to facilitate growth and economic development. Increasing funding to DEQ to manage groundwater is in line with the recommendations of the 2017 Eastern Virginia Groundwater Management Advisory Committee (EVGMAC) report.[206]

Such funding could be used to create a model that examines the full range of costs of extracting groundwater, which should consider permitting fees, well installation fees,[207] energy

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[200] Eastern Virginia Groundwater Management Advisory Committee, Minutes for #7 meeting on Apr. 17, 2017, at 5 http://townhall.virginia.gov/L/GetFile.cfm?File=meeting\53\25864\Minutes_DEQ_25864_v2.pdf.
[201] *Id.* at 6.
[202] *Id.* at 8.
[203] *Id.* at 6-7.
[204] *See* Stephenson Report, *supra* note 40.
[205] JoAnn Burkholder et al., *Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality*, ENVTL. HEALTH PERSP., https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817674/.
[206] EVGWMAC Report 2017, *supra* note 31, at 44.
[207] *See, e.g.*, Stefanos Xenarios & Paul Pavelic, *Assessing and forecasting groundwater development costs in Sub-Saharan Africa*, 39 WATER SA 529 (2013), http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1816-79502013000400010.

costs to pump water out of the well,[208] filtration and the costs to ensure quality,[209] and maintenance.[210] Externalities of increased groundwater withdrawal include risk of salt-water intrusion,[211] depletion effects,[212] and property damage due to land subsidence.[213] Subsidence is a particularly pressing consideration; subsidence caused by groundwater extraction can be irreversible when compacting soils leave no room for water to settle.[214]

Additionally, the Commonwealth should provide DEQ with funding for full assessments of surface water resources. Such a model which examines the costs of extracting surface water should consider permitting fees, withdrawal infrastructure,[215] retention infrastructure,[216] energy costs and infrastructure to move water,[217] filtration and treatment,[218] and maintenance.

Externalities of increased surface water withdrawal include potential environmental degradation and depletion effects. For instance, new reservoirs also come with environmental impacts such as wetland loss and stream depletion that, depending on the plan, can open the door to legal challenges. This was demonstrated by the court case concerning the proposed King William Reservoir in Virginia.[219] Due to statutory constraints, the U.S. Army Corps of Engineers ("the Corps") cannot issue a permit to discharge dredged or fill material into wetlands and other waters of the United States when "there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences[,]"[220] nor when the Corps' district engineer determines that it would be contrary to the public interest.[221] The Court concluded that the reservoir planned in this case did not clearly meet either of these standards because 1) water conservation programs and enhancement of existing groundwater resources were viable options the Corps did not consider,[222] and 2) the wetlands mitigation plan proposed by the developers did not sufficiently prove there would be "no net loss" of wetlands[223] after the reservoir was completed, flooding "over 1,500 acres of land, [requiring] the excavation, fill, destruction and flooding of approximately 403 acres of freshwater wetlands, and the elimination of 21 miles of free-flowing streams."[224] Thus, caution is advised when constructing a reservoir that requires the elimination

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[208] Jon Strand, *The Full Economic Cost of Groundwater Extraction*, 6 (The World Bank, Policy Research Working Paper 5494, 2010), https://www.zaragoza.es/contenidos/medioambiente/onu/758-eng.pdf.
[209] Xenarios & Pavelic, *supra* note 207, at 39.
[210] C.J. Martin, *Handford Site Groundwater Monitoring and Performance Report of 2009*, U.S. Dep't of Energy, app.B (2009), https://www.hanford.gov/c.cfm/sgrp/GWRep09/html/gw09_Appendix_B.pdf.
[211] *See Stephenson Report*, *supra* note 40.
[212] *Supra* discussion at § (III)(B).
[213] Moran et al., *supra* note 42.
[214] Leonard F. Konikow & Eloise Kendy, *Groundwater depletion: A global problem*, 13 HYDROGEOLOGY J. 317, 318 (2005), https://link.springer.com/content/pdf/10.1007/s10040-004-0411-8.pdf (describing land compaction from groundwater withdrawals as "irreversible").
[215] JLARC Report 2016, *supra* note 34, at 2.
[216] *Id.*
[217] *Id.*
[218] *Id.*
[219] *All. to Save the Mattaponi*, 606 F. Supp. 2d at 126.
[220] *Id.* at 124 (*quoting* 40 C.F.R. § 230.10(a)).
[221] *Id.*
[222] *Id.* at 130.
[223] *Id.* at 136.
[224] *Id.* at 126.

of streams and wetlands; mitigation plans have to be completed with ample detail to ensure the reservoir's harm to the environment is adequately mitigated for the purpose of securing a permit.

Conversely, permit approval for Cobbs Creek Reservoir in Virginia proceeded with little trouble.[225] While the King William reservoir would have flooded over 1,500 acres of land, and filled in 403 acres of wetland,[226] the Cobbs Creek Reservoir will cover 1,100 acres[227] and roughly 31 acres of wetlands.[228] Furthermore, the plaintiffs challenging the permit granted for King William Reservoir asserted it would impact the shad fisheries of a Virginia tribe,[229] and no such claim has arisen regarding the Cobbs Creek Reservoir. However, each reservoir project comes with its own set of unique factors that prohibit a clear comparison between the stories of the King William and Cobbs Creek reservoirs.[230] Ultimately, both DEQ and permit applicants have learned from prior projects and permit processes, resulting in improved reservoir projects.[231] Thus, a viable model which measures the full costs of surface water use must consider the costs of this planning and wetland mitigation when constructing reservoirs.

VI. CONCLUSION

Virginia's water resources require effective management in order to maintain and improve them. Under the current legal schema, DEQ can only use permitting to regulate the largest withdrawers. As demand for water increases and climate effects create additional uncertainty, policy must meet this shift to reduce demand for water or improve the quantity of and/or access to existing supplies. This begins in the water-planning phase, and trickles down to implementation policies for conservation, reclamation, reuse, and infrastructure construction. To make effective policy, more data is needed to construct an effective cost-benefit analysis of various water resources, and regional cooperation would serve to improve efficiency. Once the total costs are understood, cost-benefit analysis can reveal which investments to make in monitoring, construction, or water conservation. Ample examples of policies exist in states such as California, North Carolina, and Georgia from which Virginia may draw inspiration and develop its own approach. Ultimately, new policy measures will likely require regional cooperation and new funding.

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[225] Elliot Robinson, *Henrico's Cobbs Creek Reservoir project moving forward,* Richmond Times-Dispatch, Jul 17, 2016, https://www.richmond.com/news/local/henrico/henrico-s-cobbs-creek-reservoir-project-moving-forward/article_7a6ec63d-98e3-5382-84d5-9a4841dcdf7f.html.
[226] *All. to Save the Mattaponi*, 606 F. Supp. at 126.
[227] Ted Strong, *Officials trying to tie up loose ends on reservoir,* RICHMOND TIMES-DISPATCH, Jan. 17, 2015, http://www.richmond.com/officials-trying-to-tie-up-loose-ends-on-reservoir/article_f7f59390-bf57-5d8a-a8f5-f96f70eee86d.html.
[228] Va. Dep't of Envtl. Quality, Letter on Approval of Permit Number 05-0852, Cobbs Creek Reservoir (Dec. 3, 2015), http://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterResources/SW_WithdrawalPermits/05-0582_PermitMiMod5_CobbsCreekRes2015.pdf.
[229] *All. to Save the Mattaponi*, 606 F. Supp. at 135.
[230] Telephone interview with Brenda Winn, Senior Program Coordinator of the Virginia Water Protection Permit Program, Va. Dept. of Envtl. Quality (Apr. 12, 2018).
[231] *Id.*